AD-A230 737

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. Agency Use Only *(Leave blank).*

2. Report Date.
1990

3. Report Type and Dates Covered.
Proceedings

4. Title and Subtitle.
Transient Signal Distortion in a Multipath Environment

5. Funding Numbers.
Program Element No. 61153N
Project No. 03202
Task No. OHO
Accession No DN257015

6. Author(s).
R. L. Field

7. Performing Organization Name(s) and Address(es).
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

8. Performing Organization Report Number.
PR 90:037:244

9. Sponsoring/Monitoring Agency Name(s) and Address(es).
Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

10. Sponsoring/Monitoring Agency Report Number.
PR 90:037:244

11. Supplementary Notes.
OCEANS

12a. Distribution/Availability Statement.
Approved for public release; distribution is unlimited.

12b. Distribution Code.

13. Abstract *(Maximum 200 words).*

The classification of transient signals is facilitated if propagational distortion is removed. This distortion can be removed if the ocean impulse response from source to receiver is known. The ocean impulse response is, however, very sensitive to source location and the ocean environment. It is shown that for a bottom-mounted receiver and almost normal incidence, distortion of a 244-Hz transient signal envelope can be accounted for if the time delays and relative amplitudes of the ocean impulse response are accurately known. These time delays and amplitudes are extracted from transient data for the known source case. This work provides the motivation for the development of high-resolution, time-delay estimation algorithms to be presented in a companion paper. These algorithms will be tested on the data presented in this paper for the unknown source case.

14. Subject Terms.
(U) Transients; (U) Distributed Sensors; (U) Coherence: (U) Detection; (U) Classification

15. Number of Pages.
4

16. Price Code.

17. Security Classification of Report.	18. Security Classification of This Page.	19. Security Classification of Abstract.	20. Limitation of Abstract.
Unclassified	Unclassified	Unclassified	SAR

TRANSIENT SIGNAL DISTORTION IN A MULTIPATH ENVIRONMENT

R.L. Field

Naval Oceanographic and Atmospheric Research Laboratory
Stennis Space Center, MS 39529-5004

ABSTRACT

The classification of transient signals is facilitated if propagational distortion is removed. This distortion can be removed if the ocean impulse response from source to receiver is known. The ocean impulse response is, however, very sensitive to source location and the ocean environment. It is shown that for a bottom-mounted receiver and almost normal incidence, distortion of a 244-Hz transient signal envelope can be accounted for if the time delays and relative amplitudes of the ocean impulse response are accurately known. These time delays and amplitudes are extracted from transient data for the known source case. This work provides the motivation for the development of high-resolution, time-delay estimation algorithms to be presented in a companion paper. These algorithms will be tested on the data presented in this paper for the unknown source case.

INTRODUCTION

Transient source extraction can be formulated as a time and spatially invariant deconvolution problem if the source has been localized in a well-known environment. If these conditions are met, then the received signal r(t), can be represented by the following convolution integral:

$$r(t) = \int_{-\infty}^{+\infty} s(u)\, g(t - u)\, du$$

$$= s(t) * g(t) , \qquad (1)$$

where s(t) is the desired signal and g(t) is the ocean impulse response or Green's function. The asterisk denotes convolution. (Since the transient signal is assumed to have a high signal-to-noise ratio, no noise is considered in the equations.) If the source has been localized and the environment is accurately known, then an approximation to g(t) can be calculated with an appropriate acoustic propagation model.[1] This model response will be denoted by $g_m(t)$.

The desired s(t) can be obtained by deconvolving r(t) with the inverse of the impulse response computed by the model, $g_m^{-1}(t)$. Convolving both sides of equation 1 with $g_m^{-1}(t)$

$$\hat{s}(t) = r(t) * g_m^{-1}(t)$$

$$= s(t) * [g(t) * g_m^{-1}(t)]$$

$$= s(t) * \hat{\delta}(t) , \qquad (2)$$

where $\hat{s}(t)$ is an estimate of the desired source function and $\hat{\delta}(t)$ is an approximation to the delta function. If $\hat{\delta}(t)$ is to be a reasonable estimate to $\delta(t)$ and, therefore, $\hat{s}(t)$ is to be a good estimate of s(t), then the environmental parameters used in the propagation model and the source location must be accurately known.

In general, neither the environment nor the source location will be known accurately enough for $\hat{\delta}(t)$ to be a reasonable approximation to $\delta(t)$. A major reason why equation 2 fails is the sensitivity of the received signal on the time delays of g(t) The time delays considered here are due to multipaths.

This paper provides the motivation for development of the high-resolution, time-delay estimation algorithms discussed in a companion paper.[2] These

CH2858-9/90/0000-0111 $1.00 © 1990 IEEE

91 1 14 028

high-resolution algorithms use the approximate source location and environmental information contained in the model ocean impulse response to extract an unknown source function from the received signal. In this work, the transient data on which these algorithms are being tested are discussed and (almost) optimum time delays and amplitudes which these algorithms should find are determined.

TRANSIENT DATA/MODEL IMPULSE RESPONSE

Transient data were gathered in the Atlantic Ocean on a bottom-mounted hydrophone in 780 m of water. The experimental geometry is shown in figure 1. The acoustic source was at a depth of 40 m and transmitted the 244-Hz gated sinusoid shown in figure 2. The source signature was recorded from a hydrophone

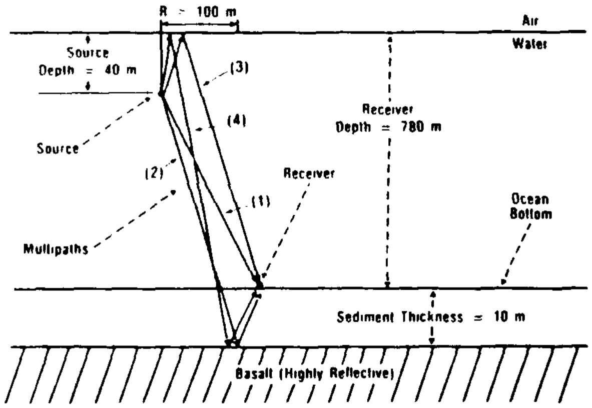

Figure 1. Experimental geometry.

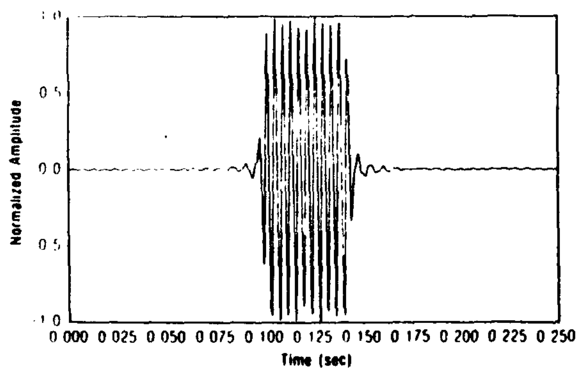

Figure 2. Source function: 244-Hz gated sinusoid.

mounted on the source. The source transmitted the gated sinusoid as the ship drifted over the bottom hydrophone shown in figure 1. The range is estimated to be 100 m.

The ocean bottom is characterized by a thin sediment layer over a highly reflecting basalt (see figure 1). The sediment varies from 0 to 20 m. For this problem, a 10-m sediment thickness was chosen.

The received signals from transmissions 3 minutes apart are shown in figures 3a and 3b. The signals received in this environment were modeled with the fast field program, SAFARI.[3] A broadband Gaussian pulse is used to model the impulse response, $g_m(t)$. The model predicts the four paths shown in figure 1. Path 1 is the direct path, path 2 is the reflection off the basalt, path 3 is surface reflected, and path 4 is reflected off the basalt from another surface reflection. The model response corresponding to figure 3a is shown in figure 4 with the four paths labeled.

It was found that repeated calculations of $g_m(t)$ were not sufficiently accurate

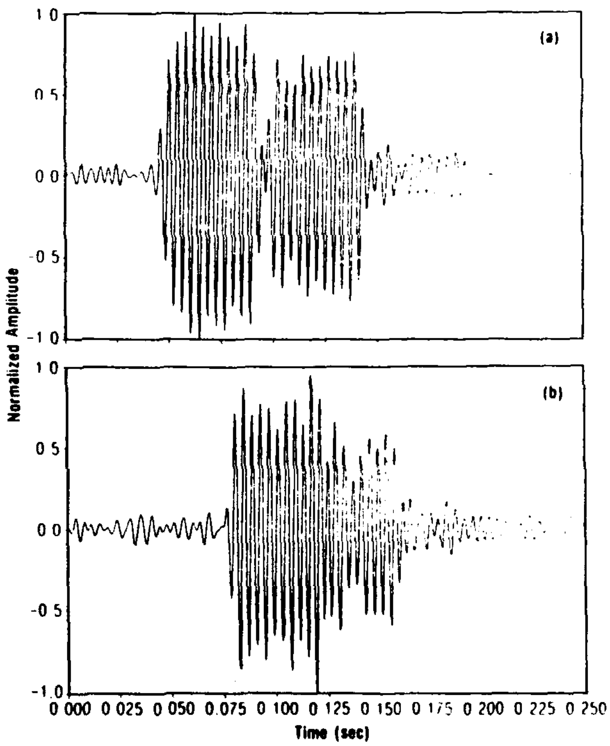

Figure 3. (a) Received data, and (b) received data (3 minutes later).

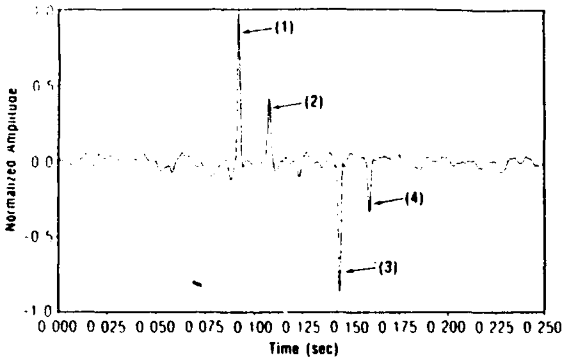

Figure 4. Broadband Gaussian-pulse propagated with SAFARI, source depth = 40 m, range = 0.1 km.

to reconstruct either of the received signals shown in figure 3. Small changes (two or three sample points, 2000-Hz sample rate) in any of the three time delays (figure 4) produced large variations in the shape of the received signal being modeled.

EXTRACTION OF (ALMOST) OPTIMUM TIME DELAYS AND AMPLITUDES

In order to determine if the model predicts the correct form of g(t), an inverse filter of the source function (figure 2) is computed. Applying this inverse, $s^{-1}(t)$, to the received signals of figures 3a and 3b

$$
\begin{aligned}
\hat{g}(t) &= r(t) * s^{-1}(t) \\
&= g(t) * [s(t) * s^{-1}(t)] \\
&= g(t) * \hat{\delta}_s(t) \ , \qquad (3)
\end{aligned}
$$

where $\hat{g}(t)$ is the impulse response estimated from the received signal and $\hat{\delta}_s(t)$ is the band limited approximation to the delta function for the known source s(t). The estimated impulse responses of the received signals shown in figures 3a and 3b are displayed in figures 5a and 5b, respectively. The responses have been bandpass filtered from 150 to 400 Hz. Since s(t) is accurately known, $\hat{g}(t)$ should be a reasonable estimate of g(t).

Assuming the model response, $g_m(t)$ (figure 4), is correct in general form, the four events labeled in figures 5a and 5b should be the desired time delays

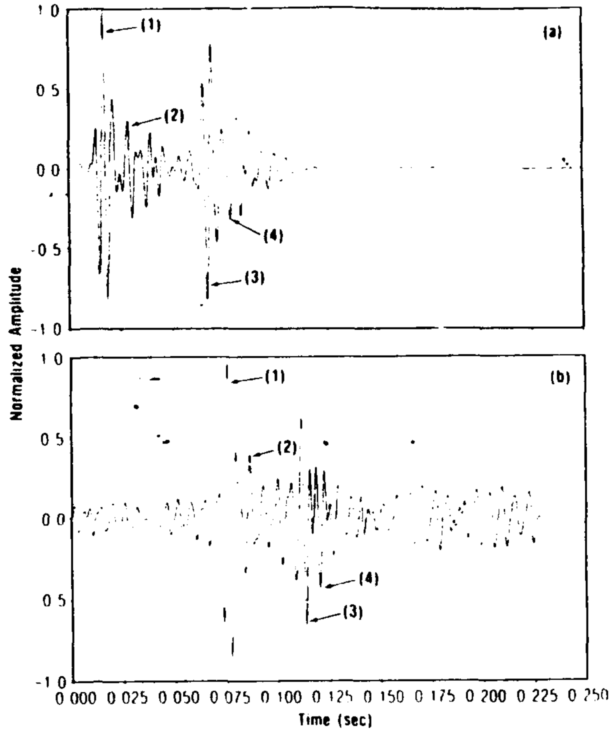

Figure 5. (a) Estimated impulse response function; $\hat{g}(t)$, and (b) estimated impulse response (3 minutes later).

and amplitudes. These are extracted from the two estimated responses and displayed in figures 6a and 6b.

To determine if these extracted paths reproduce the received signals, the waveforms of figures 6a and 6b are convolved with the source function, s(t), shown in figure 2. The envelopes of these reconstructed signals are compared with the envelopes of the received signals. Figures 7a and 7b show the reconstructed and received signals overlaid.

CONCLUSIONS

From figure 7 it is seen that the extracted time delays and amplitudes of figures 6a and 6b give good estimates of the received signals. This also demonstrates that the model predicts the correct form of the true impulse response, but due to errors in localization and environment, the model could not be used directly to model the received signal.

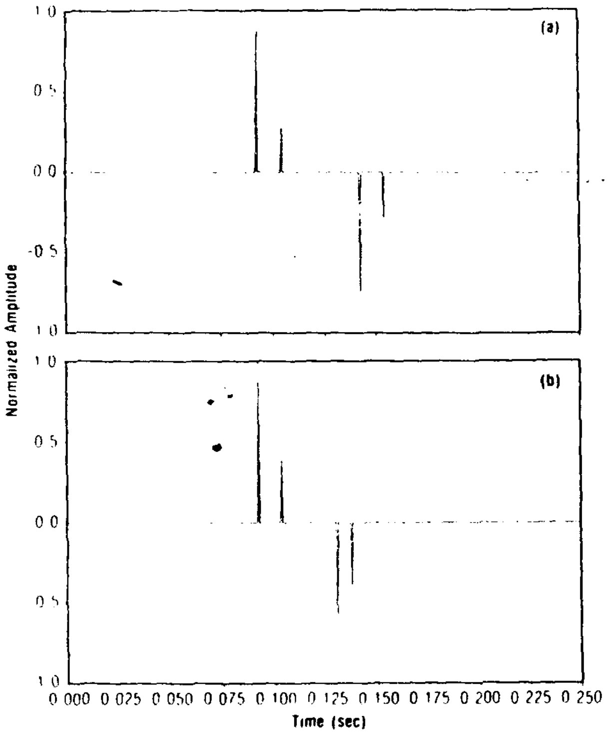

Figure 6. (a) Extracted impulse response, and (b) extracted impulse response (3 minutes later).

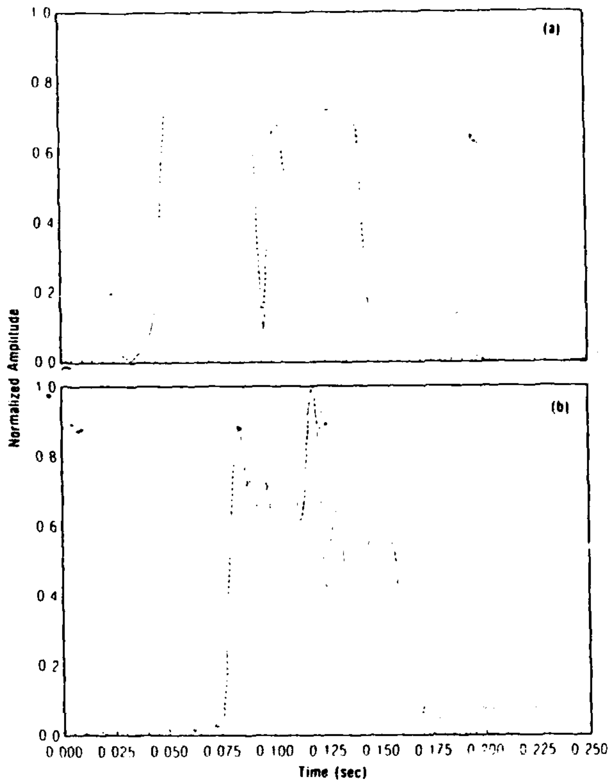

Figure 7. (a) Envelopes of received (—) and reconstructed (- - -) signals, and (b) envelopes of received (—) and reconstructed (- - -) signals (3 minutes later).

ACKNOWLEDGMENTS

This work has been approved for public release and was supported by the Office of Naval Research and the Naval Oceanographic and Atmospheric Research Laboratory (Contribution No. 90:037:244).

REFERENCES

[1]Leclere, J.H. and R.L. Field, Comparison of Time-Domain Parabolic Equation and Measured Ocean Impulse Responses, Proceedings from Oceans '90 (1990--September issue).

[2]Vaccaro, R.J., E. Maragakis, and R.L. Field, Transient Signal Extraction in a Multipath Environment, Proceedings from Oceans '90 (1990--September issue).

[3]Schmidt, H., *SAFARI (Seismo-Acoustic Fast Field Algorithm for Range-Independent Environments) User's Guide*, SACLANT Undersea Research Centre, Rep. Sk-113(1988).